Bulletins 1-4
Metallurgical Series

Bulletin No. 26. *Metallurgical Series No. 1*

University of Arizona Bulletin

CHARLES F. WILLIS, *Director.*

MILL AND SMELTER METHODS OF SAMPLING

BY H. J. STANDER.

Application for entry as second class matter at postoffice, Tucson, Arizona, applied for. Issued forty times annually.

PUBLISHED BY THE

University of Arizona
Bureau of Mines
TUCSON, ARIZONA
1915-16

MILL AND SMELTER METHODS OF SAMPLING

(*By H. J. STANDER*).

The idea seems prevalent among men operating small properties in the mining districts of Arizona that the smelters and custom mills do, in many cases, give false returns on ores that are sent in for smelting or treatment. With a view to ascertaining the facts of the case, the Arizona State Bureau of Mines has conducted an investigation and has found that it would be utterly impractical for any smelter or mill to so falsify its method of sampling as to give low returns and still give the shipper one half of the sample to allow check assays to be made.

This bulletin is written with the idea of showing the small shipper how to sample, so that he may sample his ores before shipment and ascertain the correct valu,e so that he may have a check on the smelter. Smelter methods of sampling are also given, so that the reader may determine for himself, that, owing to the great changes in the routine and the large number of men that would be necessary in any falsifying system, the smelters could not afford to give incorrect returns.

Moreover, it must be considered that when the Copper Queen mine, for instance, ships to the Copper Queen smelter, the smelter purchases the ore precisely the same as they do the ore of the man who ships ten tons, and the sampling and umpires are done under the same conditions.

It may or it may not be true that the smelters charge exhorbitant rates, or make undue penalties, but it is certainly true that the assays made for the basis of settlement are from correct sampling.

The question of the selling of ores and information relative to the necessity for smelting charges, penalties, etc., will be discussed in a later bulletin.

The sampling of the ore forms a very important part of the operation carried out in a mill or a smelter. The reasons for systematic sampling in a concentrating plant or mill are not perhaps always the same as those in the case of a smelter. Where a company concentrates and smelts its own ore, the sampling in the mill is carried out more for a check on the work and an indication as to what is being done than for any other reasons, although the sampling here is of just as much importance as in the case where the mill sells the concentrated ore to a smelter. In the latter case, both parties usually have their own sampling departments.

When a lot of ore comes to a smelter, it is highly essential to know its composition and value. The value is calculated from assays and analyses made on various samples of the given lot of ore. One can easily see that these assays and analyses should be as near the correct figures as possible, because a very light variation in such figures may alter considerably the total value of the ore lot. It is possible to assay and analyze quite accurately, and the results will be quite satisfactory, provided the samples used truly represent the lots of ore.

One of the chief problems, then, to be faced by the mill or smelter, is to obtain true samples of the ore. Such sampling must necessarily be accurate if ores or metallurgical products are sold by one and bought by another company, as the total value of the ore is always calculated from the assays and analyses of the samples. We have in the United States public sampling and ore-purchasing companies, who act as disinterested parties between buyer and seller, sampling the ore for a fixed charge per ton. It is very easy to see that these sampling companies greatly facilitate the selling and buying of an ore.

Most milling and smelting companies have their own sampling departments, and always sample an ore as it comes in, whether it had been sampled previous to its shipment or not. It is impossible for such a company to treat each ore separately, both because of the cost and because of technical difficulties. Mills and smelters work continuously, and a shut down, for however short a period, means a loss in labor, power, etc., and thus to allow one lot of ore to be heated altogether by itself is a practical impossibility. From this, it is quite clear that the only way of ascertaining the amount of the valuable metals in the ore lot is by assaying and analyzing true samples of the ore.

Before discussing in full the smelter methods of sampling, it may be well to note how sampling is usually carried out in an assay or metallurgical laboratory. As every lot or sample of ore comes into the laboratory, it has a number or name attached to it. The assayer keeps a very careful record of all data in a record note-book, in which he puts down the date received, name, number, and any other necessary information. Should the sample have no number, he gives it an arbitrary one, which can be identified in the future. After all this information has been recorded, he next finds the gross weight, and if the ore is wet, two samples are taken and the moisture determined. The ore is then thrown on the sampling floor. It is an easy matter at this stage to find the net weight of the ore, as it can be done by finding the weight of the sack, box or bottle in which the ore came, and subtracting this weight from the gross weight already found. At this stage some valuable information with regard to the character of the ore can be obtained, as the ore is still in a coarse condition.

Now comes the sampling, which is done by gradual crushing, mixing and sampling down. This sampling down is very often done by hand, and the method used is called the Cornish method. This method consists in coning the heap of ore on the sampling floor, then working it down into a circular shape and cutting it into quarters by making two diameters in the circle at right angles. The sample of ore has thus been thoroughly mixed and is divided into four parts, each part forming a segment of the circle. By removing two opposite segments, and then mixing the two remaining parts together again, it becomes possible to cone half of the original amount of the ore. After it has again been coned, the operation of quartering it is repeated, and the amount is again halved. This operation is kept up until a small enough sample is obtained. The Cornish method is a common way of hand sampling and since hand sampling is still somewhat used in the smelters, it is well to be aquainted with it.

The hand sampling, as carried out in the smelter is, however, usually of a different character. It is commonly done at the smelter when the ore is unloaded by hand. As the ore is unloaded from the cars, or transferred from one place to another, the workman throws, say, every tenth shovelful on the sample heap. By this method, one tenth of the ore goes to the sample heap, which is again sampled down.

A sample may be taken from a stream of ore while it passes from one place to another, and in such a case it is called a "running sample." Such a running sample is taken either by hand or by machine, but where the sample is not taken from such a stream of ore, the sampling is done by hand.

DIFFICULTIES IN SAMPLING

When an ore contains the metals in the native form, or in small quantities of very high-grade materials, carried in barren gangue, the task of sampling is quite a hard one. It is easy to see that wehn the metal values are finely disseminated throughout the mass of the ore, the sampling is not so difficult as when the metal occurs in large masses or crystals. When one considers that the amount of ore assayed is only very small, one can realize that, should this assay-sample contain a larger or smaller percentage of crystals of the metal than there actually are in the ore, the results would be very misleading. It is thus necessary that the ore shall be crushed fine enough to distribute the metal values as evenly through the ore as possible, for even after such an ore has been crushed to 70 mesh, it can easily happen that two samples, when assayed, will vary as high as 20 per cent. Such an ore frequently contains very rich particles of metal, which break off as crushing proceeds, and it is thus possible to come to a point where one has equally sized particles of nearly pure metal gangue. To get a true sample, it is thus necessary to continue the crushing until this point is reached.

REQUISITES TO ACCURACY

The first requisite to accuracy in sampling is that the sample and reject shall be uniform in composition at each stage of division. In order that this can be the case, there must be perfect mixing and very accurate dividing. After the sample has been cut down it should be recrushed sufficiently so that the ratio of the weight of the sample to the diameter of the largest particle in the sample shall not be below a safe proportion. If these conditions are carefully adhered to and thorough cleanliness is practiced throughout the entire operation, the limit of error is brought as low as possible.

The various ways of hand sampling will not be considered.

FRACTIONAL SELECTION BY SHOGEL

When the ore is moved by a shovel, either to load or unload it, every fifth, tenth or twentieth shovelful is thrown aside for a sample, as already noted above. How much of the ore shall be required for a sample—in other words, whether the workman shall throw on to the sample heap every fifth, tenth or twentieth shovelful, is always decided by the richness of the ore and the distribution of the minerals in it. In the same way, when loading or unloading ores in sacks, every fifth, tenth or twentieth sack may be set aside to form the sample. It is now necessary to crush this sample, and after it has been crushed the same operation of taking, say, every fifth shovelful, can be repeated. This alternate cutting down of the sample and crushing it is kept up until a small enough sample is obtained. The Cornish method of sampling, as used in an assay laboratory, has already been outlined above, and quartering as used in smelters. ffl

CONING AND QUARTERING

As the crushed ore is brought into the sampling room, it is evenly deposited on the sampling floor in a large ring. The man then shovels the ore into a conical heal in the centre of the floor, while walking slowly around the ring. Only a certain amount of the ore should be shovelled up in passing once around the heap, because if too much of it is shovelled up, a part of the ore may be too much bunched. He should throw each shovelful upon the apex of the cone, thus allowing each shovelful to be evenly distributed on all sides of the cone.

When the operation has been completed, the ore is raked out into another ring by means of a shovel or hoe. It can now be once more coned or it may be shovelled into a new cone on another part of the floor. This process of reconing is repeated until the ore is satisfactorily mixed, and then the ore is flattened down to a ring once more. This last flattening down of the cone is usually done in a systematic way by walking around the heap and raking it down. The ore, in the shape of a flattened cone, is now quartered with a stick along two diameters at right angles to each other. Two opposite quarters are shovelled away and the two remaining ones are again worked into a heap. The same operation is repeated until the sample is small enough, a recrushing being done between each operation, if necessary. One difficulty is that the fine material tends to separate out of the coarser substances, and thus hinder thorough mixing. If the ore is somewhat damp, this difficulty is partly overcome. It is also highly essential that the sampling floor shall be level, clean and without cracks, and for this reason sampling floors are usually covered with iron plates.

THE SPLIT SHOVEL, RIFFLE AND JONES SAMPLER

The split shovel is a fork in which the prongs form separate scoops, each scoop being the same size as the space between two scoops. The split shovel is laid down on the ground and the ore is spread evenly over its surface. It is now raised, and the ore lying between the scoops is left on the ground while that in the scoops is thrown in a heap by itself. By this means the ore can be halved as many times as is desired.

The riffle is simply a large split shovel which has a small handle on each side, instead of one handle at the back as in the case of the ordinary split shovel. The Jones sampler has two sets of scoops of the same hize, sloping in opposite directions, instead of alternate scoops and spaces as in the case of a split shovel or riffle.

Using a Jones sampler, the ore is discharged by the two sets of scoops just as fast as it is poured on to the sampler, and is deposited in two separate heaps on the sampling floor. In these devices, it is customary to have each scoop at least four times as wide as the largest particle of ore.

Besides these devices there are also pipe and grab samples. A pipe sampler is one obtained by driving a cheese scoop sampler or pipe into the ore. This can, of course, be done while the ore is still in the sacks, cars or bins. A grab sample is one taken by dividing the surface part of the ore into squares and taking equal quantities of ore from the corners of the squares. Running samples are also sometimes taken by hand devices, such as dipping a bucket into the stream at given intervals.

An assay of an ore is always made on a dry sample, because it is impossible to obtain accurate results on a wet sample. The ore, on the other hand, is usually always damp when samples, and it is for this reason that it becomes necessary to get "moisture samples," from which the percentage of foisture in the ore can be determined. The moisture sample is always taken just before or just after the ore is weighed and the method of obtaining such a moist sample must be a rapid one. The sample cannot be recrushed or cut down, as it has to be placed in a covered part immediately. By getting the weight of the moisture sample before any evaporation has taken place and its weight after it has been allowed to dry thoroughly and getting the difference of these two weights, one can determine how much moisture there was in the ore.

MECHANICAL SAMPLING

Some automatic samplers taken in part of the stream all of the time, whereas others take all of the stream part of the time. But as the values in an ore are never evenly distributed across the stream, the former is not so efficient a method as the latter. R. H. Richards mentions seven essential features of a perfect mechanical sampler, which are:

1. It must take the whole stream of ore (wet or dry) part of the time.

2. The scoop that cuts out the sample must move completely across and out of the stream in one direction at each cut, for, if it enters from one side, and is then withdrawn on the same side without having completely crossed the stream, more ore will be taken from the side at which the scoop enters and leaves than from the other side. He also adds that although such a scoop may take part of the stream at a given time, it does take a true section across the stream and virtually takes the whole stream part of the time.

3. The scoop must move at a uniform rate, and the top of the scoop must, in all positions, be at right angles to the direction of the stream, in order to take equal proportions from all parts of the stream. This condittion, he advises, is well obtained from a vertical stream and a horizontal scoop, in the case of a revolving scoop.

4. If the scoop that cuts out the sample revolves about an axis, two sides of the scoop should converge towards the

axis in order to take equal proportions from all parts of the stream and the scoop may be adjustable to take larger or smaller proportions of the ore.

5. The interval of time between cuts should be constant.

6. The scoops must be deep and broad enough so that ore that has once gotten into them will not bound out again; and if the scoops have closed bottoms they must not be allowed to fill up so that some of the ore runs over, as this would produce a concentration of the heavy minerals, especially when the ore is carried in running water.

7. The machine should be simple and easily accessible for cleaning, to avoid danger of contaminating subsequent samples.

There are some samplers now used in mills and smelters that cover all of these points mentioned by Dr. Richards in his "Text Book on Ore Dressing." Such samplers are the Snyder, the Vezin and the Brunton.

As hand sampling requires much more labor than mechanical sampling, it is more costly, and it is impossible to have an intentional error in the case of mechanical sampling.

The size of a sample depends largely on the character of the ore. If the metal values are very evenly distributed throughout the ore, a smaller sample is required than when this is not the case. From this it will be clear that the weight of the sample taken will decrease as the size of the ore particles decrease.

A considerable part of the ore is crushed fine when mechanical sampling is used, and since such fine material is undesirable in the blast furnace, lead smelters, which heat all of their ore by blast furnaces, still use hand sampling almost exclusively in the case of oxide ores. This, however, is not the case with the sulphide ores that come to a lead smelter, because they have to be roasted and sintered before smelting, and finely crushed ore facilities roasting. Thus it is customary in a lead smelter to use mechanical sampling on the sulphide ores and hand sampling on the oxide ores.

The following describes the method of sampling in use at the Tigre Mining Co., as described in the Engineering & Mining Journal of June 6, 1914. "The sorted high grade and sorted waste are grab-sampled; the ore on its way to the mill is sampled automatically in a revolving sampler of the slotted-cone type; the concentrate is sampled by the "cheese-trier" method; the stamp mill tailings is sampled by a Scobey-sampler and the dump tailings are uniform and sampled three times per shift by hand. The bullion is sampled by dipping; the precipitate by the same method as the concenerate, and the cyanide by hand, in the tailings sluices at each discharge of the filter press. Pregnant solutions by dropping a weighted bottle into the stump tanks, but barren solutions by drip methods."

The method of sampling at the Nipissing mill is as follows: The ore is automatically sampled on its way to the desulphurizing process. The pulp is sampled by cutting the stream every six minutes.

SAMPLING AT EL PASO SMELTERY

The first sampling is done by hand during the operation of unloading. Here each fifth or tenth shovel is thrown onto the sample heap. On the concentrates each fifth shovel is taken and this sample is halved. The shovel samples are taken to the sample mill, while the concentrate samples go to the quartering floor, where they are sampled according to the coning and quartering method. The final sample here weighs about 400 pounds.

The shovel samples from the ore lots are reduced in some automatic sampling and crushing equipment. There are four sets of such automatic sampling and crushing equipments, two for ores not exceeding three inches in size, and two for coarse material.

"The samples from the finishing rolls are dried in two stream drying rooms, and thence go to two backing rooms. The duplicate samples are handled in different rooms. These rooms have four Engelbach grinders and four Eaton pulp mixers. The latter are small revolving cylinders, having several interior shelves to assist in mixing the material. From the Eaton mixer the sample is riffled down on a Jones divider and then goes to the bucking board. From the bucking board the pulp returns to a small Eaton mixer and after being revolved for a few minutes, the material is poured out and the sample is placed in the pulp envelopes.

In the above stated cases, sampling methods have been outlined as used both in the mill and in the smelter. Hand sampling can be done very conveniently in both cases, and also mechanical, but there is a better chance to get running samples in a wet-concentrating plant than there is in the case of a smelter, where the ore usually comes in in the form of dry shipments. To what extent mechanical sampling should be carried on depends greatly upon the mechanical perfection of the samplers used, especially with respect to cleanliness and to their adaptability to make the loss, which is brought about by the extreme fineness of the material, as small as possible.

In conclusion it may be worth while to point out how impractical it is for a smelter to underpay any party from whom ore is bought, as some, who have small quantities of ore for sale, very often imagine. A smelter is always willing to present a seller with half of the sample obtained at the smelter, in order that he himself can have the sample assayed, and if his results should not agree with those obtained at the smelter, the latter is furthermore willing to refer the whole matter to an umpire assayer. The regular procedure of operations as carried out at a smelter makes it almost an impossibility to get such a false sample as to specially favor itself. and this, together with its willingness to have its own assay results confirmed by the seller, makes the practice of under paying the owners of ores very much impractical. From this one concludes that when a man has some ore which he wishes to sell to a smelter, the latter will almost without exception, give him full value for his property.